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From plate to planet: nutritional and environmental sustainability of Turkish cuisine across the regions of Türkiye

Zehra Margot Çelik ^a, Hatice Kübra Barcın-Güzeldere ^b, Elif Ede-Çintesun ^c
and Hatice Merve Bayram ^d

^aFaculty of Health Sciences, Department of Nutrition and Dietetics, Marmara University, Istanbul, Türkiye; ^bFaculty of Health Sciences, Department of Nutrition and Dietetics, Istanbul Medeniyet University, Istanbul, Türkiye; ^cFaculty of Health Sciences, Department of Nutrition and Dietetics, Istanbul Sabahattin Zaim University, Istanbul, Türkiye; ^dFaculty of Health Sciences, Department of Nutrition and Dietetics, Istanbul Gelisim University, Istanbul, Türkiye

ABSTRACT

This study aims to analyze the nutrient profile, carbon and water footprints of traditional menus across geographical regions of Türkiye. The recipes were selected from cookbooks and were analyzed through Google Trends. The menus showed significantly higher levels of energy, protein, carbohydrates and several vitamins and minerals ($p < 0.05$). Carbon footprint analysis revealed Southeast Anatolia had the highest footprint (5.54 ± 0.55 kg CO₂ eq/d), while Central Anatolia had the lowest (2.01 ± 0.23 kg CO₂ eq/d) ($p < 0.05$). Water footprint data indicated Marmara had the highest values (4165.03 ± 386.95 L/kg/d), with Central Anatolia having lowest (1132.14 ± 101.18 L/kg/d) ($p < 0.05$). However, no statistically significant differences were observed between traditional menus and the EAT-Lancet Planetary Diet. These findings highlight the importance of developing sustainability strategies that preserve cultural heritage while promoting plant-based ingredients, seasonal and local foods, and eco-friendly cooking methods to mitigate environmental impact.

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Carbon footprint; water footprint; Turkish cuisine; sustainable; nutrition

Introduction

Sustainable diets are defined by the Food and Agriculture Organization (FAO) as those that are “protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources” (Lang 2012). Achieving sustainability within the food system entails meeting human needs while reducing reliance on fossil fuels, chemical inputs, and energy-intensive processes, with an emphasis on local and seasonal foods. However, current practices in food processing, packaging, transportation and consumption often fall short of these criteria. This system has led to global issues, such as obesity, malnutrition and deficiencies in macro and micronutrients, largely due to the reduced nutritional value of processed foods and the prevalence of fast-food culture; the latter promotes a sedentary lifestyle and encourages the consumption of high-energy and high-fat foods. Enhancing food quality and safety through sustainable diets has thus become essential. A sustainable dietary system should prioritize improvements in food production, especially for animal-derived products, reduce the dependence on food transport systems, minimize food processing and refining and support the consumption of local and traditional foods (Lairon 2012).

CONTACT Zehra Margot Çelik  zcelik@marmara.edu.tr  Faculty of Health Sciences, Department of Nutrition and Dietetics, Marmara University, Basibuyuk, Süreyyapasa Basibuyuk Yolu Sk No:4/B, Maltepe, Istanbul 34854, Türkiye

Different approaches have been recommended to promote sustainability in food systems. Each practice contributes to various dimensions of sustainability, including reducing energy and water use in food processing and production, as well as adjusting food proportions to positively impact environmental and economic aspects (Maynard et al. 2020). A key strategy for enhancing sustainability involves prioritizing the use of local and seasonal foods, particularly within institutional food systems. Research highlights that promoting the consumption of seasonal and locally grown vegetables and fruits fosters healthy eating habits, supports the local economy and helps preserve culinary traditions (Wallnoefer et al. 2021). Another essential approach is reducing the intake of animal-derived foods. It is well-known that increased production and consumption of animal-based foods significantly contribute to greenhouse gas emissions (GHGE) (Batistela dos Santos et al. 2022; Bayram and Ozturkcan 2022). Studies have shown that replacing animal-based diet components with plant-based options or meat alternatives results in a lower environmental impact (Risku-Norja et al. 2008; Sáez-Almendros et al. 2013; Westhoek et al. 2014; Vieux et al. 2018; Bayram and Ozturkcan 2022).

Turkish cuisine, with its rich history, cultural heritage and distinctive local flavors, stands as one of the world's most significant culinary traditions. In alignment with the Mediterranean diet, Turkish cuisine incorporates vegetables, cereals, legumes and olive oil, and is often prepared using traditional cooking techniques that promote health (Solmaz and Dd 2018). Understanding the water and carbon footprints of Turkish cuisine holds great importance for environmental sustainability, as these metrics offer crucial insights for minimizing the ecological impacts of food production (Guimarães et al. 2024). The rich diversity and alignment of Turkish cuisine with Mediterranean dietary principles offer a unique opportunity to explore the intersection of cultural heritage and sustainability. Each of Türkiye's seven geographical regions has a distinct culinary identity shaped by local ingredients, historical practices, and cultural traditions (Solmaz and Dd 2018). An analysis of these cuisines through the lens of nutritional and environmental sustainability provides valuable insights into how traditional food systems can align with modern sustainability goals. However, studies on the sustainability of Turkish cuisine – particularly those assessing carbon and water footprints – are sparse and sometimes contradictory (Üçtuğ et al. 2021; Saleki et al. 2023). To our knowledge, no research has comprehensively evaluated the relationship between carbon and water footprints and the nutrient profiles of traditional Turkish cuisine menus according to their regions. The existing literature on Turkish cuisine has primarily concentrated on its cultural and nutritional aspects, with relatively limited attention devoted to its environmental impact. For example, research by Solmaz and Altiner(2018) emphasized the health benefits of the diet in question yet failed to address the environmental footprints associated with it. Similarly, Üçtuğ et al. (2021) conducted an analysis of dietary comparisons, but overlooked the integration of nutritional profiles. A limited number of studies, including those by Saleki et al. (2023) and Bayram and Ozturkcan (2023b), have investigated the carbon or water footprints associated with dietary patterns. However, these studies have either focused on general dietary patterns or lacked a comprehensive examination of traditional Turkish menus. In order to address this gap in the literature, our study presents a systematic analysis of the relationship between the nutritional richness of regional Turkish cuisines and their associated environmental footprints.

The objective of this study is to conduct a comprehensive analysis of the interrelationship between nutrition and the environment with respect to Turkish food. The findings will contribute to the ongoing research on sustainable diets. By examining the interrelationship between carbon and water footprints and nutrition, this research offers significant insights into the ecological impact of traditional food systems. The findings may inform the formulation of dietary guidelines, and the development of public health initiatives designed to promote sustainable eating habits. In addition, they provide a foundation for decision makers to design region -specific strategies that

retain culinary heritage while encouraging sustainable practice, such as reducing addiction to animal -based ingredients and increasing the use of seasonal and locally built foods. The study also has practical applications for chefs, dietitians, and caterers who want to create environmentally friendly and nutritionally balanced menus. In light of the study's objectives, the following hypotheses were put forth: The nutritional profiles of traditional Turkish menus diverge considerably from the recommended intake levels outlined in the Turkish Dietary Guidelines (TÜBER). The carbon footprint of traditional Turkish menus exhibits considerable variation across the seven geographical regions, with higher values observed in regions that favor animal-based ingredients. The water footprint of traditional Turkish menus is significantly influenced by dietary patterns, with animal-based menus displaying higher footprints. No significant differences are evident between the environmental impacts of traditional Turkish menus and the EAT-Lancet Planetary Diet, largely due to the plant-based nature of numerous traditional dishes. Thus, in the present study, we analyzed the energy and nutrient values, carbon footprint and water footprint of menus featuring the most commonly consumed foods from each of Türkiye's seven geographical regions: Marmara, Aegean, Mediterranean, Black Sea, Central Anatolia, Eastern Anatolia, and Southeast Anatolia.

Methods

Data collection

The initial phase of the menu development process for the seven regions of Türkiye entailed the identification of the traditional local dishes that are unique to each region (Turkish Patent and Trademark Office 2024). Subsequently, the selected dishes were classified into five categories: soup, main course, side dish, salad and dessert. For each category, data from Google Trends were retrieved in order to identify the three dishes with the highest search frequencies. The standard recipes for the highest-ranked dishes were sourced from scientific references and culinary books. In instances where a standard recipe for the top-ranked dish was unavailable, the second or third-ranked dish was employed instead. This approach resulted in the formation of five discrete categories of dishes for each of the seven regions.

Google trends tool

Google Trends, a freely accessible online tool that allows users to analyze search interest in specific terms within a chosen region and timeframe, covers data since January 2004. Google Trends enables the comparison of up to five terms simultaneously and estimates the relative search volume (RSV) for each query made using the Google search engine. RSV is an index adjusted for the number of Google users in a given geographic area and time interval, ranging from 0 to 100. An RSV of 100 represents peak popularity in a specific time and location, while an RSV of 0 indicates minimal or no interest (Nutı et al. 2014; Kamiński et al. 2020; Bayram and Ozturkcan 2023a).

Google trends data

Since various geographically indicated foods vary by region, it was aimed to select dishes that attract the attention of the population and their search to make a transparent selection. The data were collected using Google Trends from 1 January 2004, to 1 May 2024, to achieve transparency. Searches were conducted separately for each region in Türkiye by applying the "All Categories" and "Web Searches" filters. The names of the selected standard traditional meals—44 from Marmara, 59 from Aegean, 51 from Mediterranean, 87 from Black Sea, 51

from Central Anatolia, 63 from Eastern Anatolia, and 68 from Southeast Anatolia – were entered individually into Google Trends according to their respective regions. RSVs for each dish were then recorded. Classification, number of meals and meal names are shown in [Table 1](#). Meals were selected to calculate the carbon and water footprint according to higher RSVs.

Evaluation of energy and nutrient content of menus

The nutritional analysis of the menus was conducted using the Nutrition Information System (BeBiS, version 9.0), a software tool widely used for dietary assessments in academic and clinical research. BeBiS offers comprehensive data on macro and micronutrient values, making it a reliable choice for nutritional evaluations. Standard recipes for the selected dishes were sourced from validated scientific references and traditional culinary books, ensuring authenticity and accuracy in nutrient calculations.

The analysis focused on estimating the energy, macronutrient, and micronutrient content of the menus, with particular attention to nutrients that are often over- or under-consumed in traditional diets, such as saturated fats, dietary fiber, sodium, and cholesterol. Additionally, vitamins and minerals essential for public health, such as vitamins A, C, B₁₂, and iron, were included in the assessment to provide a holistic overview of the nutritional profile.

Additionally, data from the Turkish Statistical Institute (2023) indicate that individuals aged 40–49 represent the highest population density in Türkiye, making this age group a relevant demographic for the calculation of nutritional requirements. This selection ensures that the findings are relevant to a significant portion of the population. Furthermore, this age group is at a critical stage where dietary habits play a pivotal role in the prevention of chronic diseases such as cardiovascular disease and diabetes, which are prevalent in middle-aged populations (Murray et al. 2020; Snetselaar et al. 2021).

Nutritional requirements were calculated in alignment with the recommendations of the Turkish Dietary Guidelines (TÜBER, 2022). This approach aligns with the guideline that lunch menus should meet 2/5 of the total daily intake. The study aimed to design lunch menus that provide 2/5 of the daily nutritional requirements for this demographic, as TÜBER guidelines suggest that lunch should account for approximately 40% of daily intake. This approach ensures that the analysis reflects real-life dietary practices and addresses the nutritional needs of this specific age group.

Calculation of carbon footprint and water footprint

Total carbon footprint (CF) is commonly assessed through the life cycle assessment (LCA) method (2006). LCA is a technique used to estimate CF across various stages of food production and consumption. Initially developed for industrial processes, LCA was adapted for food applications in the early 1990s (Roy et al. 2009). LCA is a comprehensive approach that considers all stages in a product's lifecycle, including emissions from agriculture and primary production, processing, packaging, transportation, storage, retail, preparation, cooking and waste disposal (Roy et al. 2009; Audsley et al. 2010). The carbon footprints (CFs) associated with food production primarily consist of nitrous oxide (N₂O) and methane (CH₄), which are mainly generated during primary production, along with fossil-derived carbon dioxide (CO₂). Total CF is expressed in CO₂ equivalents (CO₂eq) over a 100-year perspective, where 1 kg of CO₂ is equivalent to 1 kg of CO₂eq, 1 kg of CH₄ is equivalent to 25 kg of CO₂eq, and 1 kg of N₂O is equivalent to 298 kg of CO₂eq (Bernstein et al. 2008).

Significant discrepancies in CF levels are attributable to methodological inconsistencies (e.g. the utilization of “consequential” or “attribution” modeling) or the delineation of system boundaries, such as the inclusion or exclusion of the consumer stage in the CF calculation (Berlin et al. 2008; Thomassen et al. 2008). Although changes in land use and land management may be critical for

Table 1. Classification and number of meals.

Region	Food Category	Number of meals	Name of Meals
Marmara	Soup	4	Umaç soup* , Oğmaç soup, Termal soup, Çene Çarpan soup
	Main course	16	Sultanahmet meatball, Kırklareli meatball, Salted Sardines, Biga meatball, Fried liver, Zirva, Mutancana, Bilecik Casserole, Sura, Bigadiç Casserole, Tirit, Tekirdağ meatball, Islama meatball, Stuffed quince with molasses, Iskender Kebab, Inegöl Meatball*
	Side dish	8	Sarıyer pastry, Kaldırık roast, Labada borani, Kupriva, Melki dish, Zırz, Bozüyük Manti with Lentils, Cantik*
	Salad	4	Eggplant pickle, Manca* , Mamzana, Circassian Chicken
	Desert	12	Pişmaniye, Eşme quince dessert, Cheese halva, Kavala cookies, Bilecik Pazaryeri halva, Höşmerim, Yalova milky, Pumpkin dessert, Tahanlı Pide, Chestnut candy* , Milk halva, Kemalpaşa dessert
Aegean	Soup	8	Kulak soup, Black-eyed peas tarhana soup, Sıkıkcık soup, Sakala Çarpan Soup, Tarhana soup* , Ingil (Tingil) soup, Dried broad bean soup, Mürdümük soup
	Main course	19	Çine meatball, Dalama tandoori, Aydın roll, Bread stuffing, Milk sea bass, İzmir meatball, Papaz Yahnisi, Bergama meatball, Akhisar meatball, Salihli Ahşap meatball, Manisa kebab, Keşkek* , Parsley Moussaka, Çullama meatball, Bodrum mantı, Milas sour meatball, Çökertme kebab, Kefal stuffed
	Side dish	13	Çiğirtma, Stuffed artichoke, Stuffed zucchini flower, Scraped zucchini, Black-eyed peas tarator, Black-eyed peas pie, Yen pastry, Stuffed vine leaves with olive oil* , Bulghur pilaf with poppy seeds, Muğla pilaf with black-eyed peas, Stuffed mushroom, Mallow roast, Tilkişen roast
	Salad	5	Cretan Paste, Meneviş yogurt sauce, Black-eyed peas salad, Rock grove salad, Radish salad*
	Desert	14	Pumpkin dessert, Sambali Dessert, İzmir bomb, Tangerine dessert, Lokma* , Mushroom dessert, Şehzade dessert, Akaşı, Milk fig dessert, Dügülü poppy dessert, Höşmerim, Clotted bread kadayıf, Demir dessert, Zerde
Mediterranean	Soup	8	Oğmaç soup, Mürdümek soup, Arabası soup* , Hülüklü soup, Millet soup, Anali kızılı soup, Yüksük soup, Tırşik soup
	Main course	15	Banak, Carp stuffed, Testi kebab, Plum meat, Göleviz dish, Tarsus kebab, Mersin tantuni, Adana kebab* , Adana şırdan, Liver roast, Mumbar stuffed, Eli böğüründe, Sömelek meatballs, Tepsi kebab, Kağıt kebab
	Side dish	10	Sülük aşı, Tatar, Squash flower stuffing, Tarsus, Fındık lahmacun, Adana stuffed meatballs* , Okra stuffing, Fellah meatballs, Adana pastry, Avgan pilaf, Acem pilaf
	Salad	6	Hibeş, Tahini piyaz, Tarsus hummus, Zahter salad, Hummus*, Babagannuş
	Desert	12	Water jelly, Fig stuffing, Burdur pudding, Carrot dessert, Hemp dessert, Poppy seed halva, Kerebiç, Adana stone kadayıf, Maraş ice cream, Çullama, Künefe* , Cheese semolina halva
Black Sea	Soup	18	Cornelian cherry tarhana, Bolu style highland soup, Uğmaç soup, Pumpum soup, Pınarbaşı black soup, Corn soup* , Tutmaç aşı, Spinach soup, Haluçka soup, Bean corn soup, Toyga soup, Beetroot soup, Karalahana soup, Katıklı soup, Kesme soup, Anchovy soup, Nettle soup, Püşürük soup
	Main course	26	Abant kebab, Orman kebab, Bolu mantı (with mushrooms), Düzce meatballs, Tirit, Flour stuffed ispit, Taşköprü well kebab, Kastamonu tiridi, Boyabat pole kebab, Sinop lakerda, Sinop mantı, Palamut pilaki, Iskilip stuffed, Çorum stew, Brown bean wrap, Kidney wrap, Anchovy in paper, Tokat kebab, Yalıköy meatballs, Anchovy bulama, Anchovy meatballs, Anchovy bird, Akçaabat meatballs, Fried anchovy* , Anchovy pilaf, Rize roast
	Side dish	21	Bolu Pumpkin gözleme, Pasha pilaf, Kaldırık dolma, Mengen pilaf, Konuralp pilaf, Leek mancar, Egg zılbit, Pumpkin pastry, Döşemeli mancar, Sour pilaf, Chestnut stuffed pilaf, Söbelek stuffed pilaf, Çiğdem pilaf, Bat* , Stuffed vine leaves, Bean dibble, Chard fritters, Karalahana dibble, Borani, Lot of curd, Kale sarma
	Salad	2	Düzce ajika, Roasted pickles*
	Desert	20	Bolu Goynuk Ugut Dessert, Höşmerim, Saray halva, Akçakoca melengüceği dessert, Seku, Halışka, Fig dessert, Zirva, Ağda dessert, Çekme halva, Nokul* , Lemon pazule, Koca karı gerdan dessert, Kabataş halva, Perşembe walnut halva, Hamsiköy Sütlacı, Milk pastry, Laz pastry, Pepecura, Hasuta

(Continued)

Table 1. (Continued).

Region	Food Category	Number of meals	Name of Meals
Central Anatolia	Soup	13	Yarmalı köy tarhana, Tutmaç soup, Çankırı cimcik dough soup, Bitbit soup, Arabaşı soup, Okra soup* , Bulamaç soup, Flour soup, Yoghurt beet soup, Kesme aşı, Çullama, Peskütan soup, Helle soup
	Main course	16	Ankara Tava, Beypazarı stew, Tulum kebab, Çankırı garlic meat, Balaban meatballs, Kayseri mantrı* , Kayseri tiridi, Kayseri yağlama, Çirleme, Ayva borani, Baked beans in a pot, Tirit kebab, Stuffed quail, Nevşehir Testi kebab, Sivas meatballs, Yozgat Tandır Kebab
	Side dish	9	Chiborek, Hot stuffed peppers, Quince stuffed peppers, Beetroot stir-fry, Lepe, Batırık, Hingel, Madımak* , Divriği pilaf
	Salad	1	Pickled Pezik (beet twig)*
	Desert	12	Beypazarı baklava, Haside dessert, Aksaray şugar pastry, Aksaray foam halva, Çankırı egg dessert, Höşmerim dessert, Çankırı ehlibilir dessert, Çankırı hameyli dessert, Met halva* , Aside/Haside, Nevzide, Kalburabastı
Eastern Anatolia	Soup	9	Gari aşı, Aşor soup, Ayranası, Tutmaç soup, Dövme soup, Kesme soup* , Omaç aşı soup, Virik soup, Girar soup
	Main course	25	Büryan kebab, Katıklı dolma, Abdigor meatballs, Gösteberg Meat, Selekeli, Trout, Goose meat, Stuffed ribs, Harput meatballs, Kumi kebab, Küncülü meatballs, Yaprak döner, Meat stuffed vine leaves, Lamb dolma, Çağ kebab, Stone meatball dish, Bozbaş, Katlet, Geleli kebab, Stuffed meatballs* , Analı kızılı, Corti aşı, Muş meatballs, Acem meatballs, Baked Pearl Mullet
	Side dish	17	Noodles, Hengel, Keledoş, Haşıl* , Mastuva, Gulik, Pounded rice, Turnip dolma, Curd dolma, Water pastry, Caşır kavurma, Zibilli rice, Arapgir dolma, Cherry leaf dolma, Hasut dolma (hez), Helise, Çiriş mihlaş
	Salad	2	Pickled Corti, Van Cacik*
	Desert	10	Wild pear lokma, Hasude, Mafış Dessert, Umaç Halva, Mulberry dessert, Molasses halva, Dolanger, Kasefe dessert, Stuffed kadayif* , Çatal Dessert
Southeast Anatolia	Soup	11	Meyir soup, Lebeniye soup, Ayran soup, Diyarbakır Habenisk Soup, Öz soup, Alaca soup, Börek soup* , Ezogelin soup, Beyran, Mahluta soup, Pırpıt soup
	Main course	27	Rib dolma, Mumbar dolma, İkbebet, Onion Kebab, Fırkiye, Besni tava, Stuffed meatballs, Quince meatballs, Meftune, Liver Kebab* , Plum, Tırşik, Şiveydz, Kabaklama, Alinazik, Antep Lahmacun, Plum tava, Yenidunya kebab, Küşleme kebab, Simit kebab, Keme kebab, Kilis tava, Ekşili kebab, Şihıl maşşi, Siir büryan kebab, Eggplant kebab, Urfa kebab, Liver kebab
	Side dish	12	Çiğköfte, Kahta bulgur pilaf, Garlic bulgur pilaf, Dry stuffed vegetables* , Damascus pastry, Perde pilaf, Duvaklı pilaf, Kenger boranisi, Pimpirim aşı, Tene katması, Malhitalı meatball, Üzlemeli pilaf
	Salad	5	Dövmeç, Purslane cacik, Babaganuc, Mash piyaz, Bostana*
	Desert	13	Harire, Kahta almond semolina halva, Cheese semolina halva, Şıllık dessert, Diyarbakır pear dessert, Burma kadayıf, Dolangel dessert, Antep baklava, Katmer* , Heaven mud, Gerebiç, Gebole, Cizre luzine dessert

*shows the selected dishes according to their RSVs.

food production due to biogenic CO₂ emissions (Foley et al. 2011), there is no agreement on how to calculate these emissions.

Due to the lack of data on carbon footprint (CF) and water footprint (WF) values for foods produced in Türkiye, we used the Su-EATABLE LIFE (SEL) database. This database is a harmonized compilation of CF and WF values for various food commodities, based on a standardized methodology that draws from peer-reviewed articles and grey literature to assign optimal footprint values and associated uncertainties (Pettersson et al. 2021). The SEL database was selected for its reliability, extensive coverage, accessibility and recent publication. It provides values for each food item in the desired functional unit of kg CO₂-eq. Additionally, SEL includes updated

and harmonized data, with 3,349 carbon footprint values derived from 841 publications (1998–2019) and 937 water footprint values sourced from 88 publications (2005–2018) (Petersson et al. 2021).

The EAT-Lancet Planetary Diet was used as the basis for a comparison of the carbon and water footprints of traditional menus across a range of geographic regions. The EAT-Lancet Planetary Diet is comprised of 2500 kcal/day and is predominantly plant-based in composition (Willett et al. 2019). The planetary diet was developed with health considerations in mind and is intended to delineate empirically derived food groups and ranges of food intakes to optimize human health. It is recommended that the planetary diet be adapted to align with the cultural, geographical and demographic characteristics of the populations in question. The recommended planetary diet was used as a point of comparison for traditional menus. Initially, the carbon and water footprints of all foods in the planetary diet were calculated and then multiplied by $\frac{2}{3}$ to enable comparison with the traditional menus.

Statistical analyses

The data were analyzed using the statistical software package SPSS 25.0. The normality of each variable was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on the results of these tests, normally distributed variables were analyzed using one-sample t-tests for comparisons with dietary reference intakes, including protein (%), fat (%), omega-3 (g), carbohydrate (g and %), vitamin A (mcg), vitamin E (mg), vitamin K (mcg), vitamin C (mg), vitamin B1 (mg), vitamin B2 (mg), vitamin B6 (mg), vitamin B12 (mcg), vitamin B5 (mcg), biotin (mg), folate (mcg), sodium (mg), potassium (mcg), calcium (mg), iron (mg), and zinc (mg). Meanwhile, non-normally distributed variables were analyzed using one-sample Wilcoxon signed-rank tests, including energy (kcal), cholesterol (mg), fiber (g), phosphorus (mg), and magnesium (mg). The Kruskal-Wallis test was employed to determine differences in carbon and water footprints across regional menus and the EAT-Lancet Planetary Diet, as these data did not follow a normal distribution. Statistical significance was set at $p < 0.05$ for all analyses.

Results

The energy, macronutrient and micronutrient content of the traditional menus with the highest RSVs are presented in Table 2. The findings indicate that the traditional menus of all seven regions exceed the Turkish Dietary Guideline (TDG) recommended reference intakes for energy, carbohydrates and several vitamins and minerals, including vitamins A, E, K, B₁, B₂, B₅, B₆, and B₁₂, folate, sodium, potassium, phosphorus, iron and zinc. The data revealed that cholesterol levels exceeded the TDG recommendations in all regions except the Black Sea, where they were below the recommended threshold.

The fiber content exhibited notable variability. The traditional menus from the Marmara and Southeast Anatolia regions exhibited lower fiber content, while the other five regions demonstrated higher fiber levels. Concerning vitamin C, the levels were found to be lower in the traditional menus of the Marmara and Eastern Anatolia regions, while they were higher in the other five regions. Biotin levels were observed to be lower in the Central Anatolia region, but higher in the remaining six regions. Additionally, the Southeast Anatolia region exhibited lower calcium and magnesium levels, while the traditional menus of the remaining regions exceeded the recommended levels. All observed differences were statistically significant except cholesterol and vitamin K.

Table 3 shows the mean carbon and water footprint levels of traditional menus from seven Turkish regions compared with the EAT-Lancet Planetary Diet. The traditional menu of the Southeast Anatolia region had the highest carbon footprint, while the menu from the Marmara region exhibited the highest water footprint. When sorted by carbon footprint, the regions, ranked from highest to lowest, were Southeast Anatolia, East Anatolia, Marmara, Aegean, Mediterranean,

Table 2. The energy, macronutrient, and micronutrient contents of the traditional menus with the highest RSVs.

	Marmara		Aegean		Mediterranean		Black Sea		Central Anatolia		East Anatolia		Southeast Anatolia		TDG Man		t/Z		TDG Woman		t/Z	
Energy (kcal)	1952.97	1700.9	2313.17	1662.69	1039.4	2656.77	1067.73	971.6**	1.580	0.114	773.6**	2.803	0.005									
Protein (E %)	106	50	75	107	72	61	101	4.8*	13.560	<0.01	4.8*	4.756	<0.01									
Fat (g)	101.96	93.3	119.23	80.46	51.41	84.71	55.15	-	-	-	-	-	-									
Fat (E %)	232	274	240	219	205	190	190	8*	19.629	<0.01	8*	19.629	<0.01									
Saturated fatty acids (g)	26.06	27.68	40.79	11.3	26.25	37.51	13.18	-	-	-	-	-	-									
MUFA (g)	42.2	12.57	18.32	43.71	6.03	15.38	21.07	-	-	-	-	-	-									
PUFA (g)	28.32	46.19	54.45	18.27	14.88	27.11	16.25	-	-	-	-	-	-									
Omega 3 (g)	5.9	1.35	1.57	5.52	0.59	2.64	0.41	0.1*	3.388	<0.01	0.1*	3.388	<0.01									
Omega 6 (g)	36.23	11.2	16.74	38.05	5.44	12.67	20.58	-	-	-	-	-	-									
Cholesterol (mg)	392.31	154.24	204.03	36.58	134.92	362.57	256.47	120**	2.395	0.017	120**	2.395	0.017									
Carbohydrate (g)	155.56	166.65	230.58	143.64	107.46	400.74	96.86	52*	4.876	<0.01	52*	4.876	<0.01									
Carbohydrate (% E)	158	175	183	175	224	249	210	18*	12.098	<0.01	18*	12.098	<0.01									
Fiber (g)	8.3	20.72	27.11	25.26	20.32	22.54	9.84	10**	2.803	0.005	10**	2.803	0.005									
Vitamin A (mcg)	389.55	719.17	523.26	938.45	2004.72	579.05	11112.74	300*	3.548	0.006	300*	3.548	0.006									
Vitamin E (mg)	25.32	14.84	11.28	39.8	10.26	9.77	25.95	5.2*	4.142	0.005	5.2*	4.142	0.005									
Vitamin K (mcg)	80.95	203.53	78.25	290.74	58.73	51.98	139.58	28*	2.171	0.001	28*	2.171	0.001									
Vitamin C (mg)	30.23	108.77	71.47	132.7	236.15	36.38	101.4	44*	0.058	0.015	44*	0.058	0.015									
Vitamin B ₁ (mg)	0.71	0.77	1.78	1.31	0.62	0.97	0.58	0.16*	8.140	<0.01	0.16*	8.140	<0.01									
Vitamin B ₂ (mg)	1.4	0.83	1.11	1.7	1.25	1.08	2.26	0.64*	5.014	<0.01	0.64*	5.014	<0.01									
Vitamin B ₆ (mg)	1.73	1.03	1.59	2.13	0.89	1.42	1.28	0.68*	3.912	0.004	0.64*	3.912	0.004									
Vitamin B ₁₂ (mcg)	6.58	3.29	2.71	1.64	36.58	5.92	42.82	1.6*	3.781	0.004	1.6*	3.781	0.004									
Vitamin B ₅ (mcg)	4.51	3.18	3.09	6.9	1.87	3.73	6.38	2*	3.455	0.007	2*	3.455	0.007									
Biotin (mg)	43.53	18.49	27.99	61.43	14.65	40.9	77.36	16*	4.858	<0.01	16*	4.858	<0.01									

(Continued)



Table 2. (Continued).

	Marmara	Aegean	Mediterranean	Black Sea	Central Anatolia	East Anatolia	Southeast Anatolia	TDG Man	TDG Woman	t/Z	p
Folate (mcg)	236.73	296.85	338.91	390.11	444.24	166.67	495.47	132*	132*	3.875	0.004
Sodium (mg) ⁺	4476.65	2812.87	20242.35	4284.61	2726.13	4042.21	2993.09	800*	800*	3.818	0.004
Potassium (mcg)	1854.17	2341.08	2409.12	2811.61	2068.33	1963.67	1679.46	1400*	1400*	6.856	<0.01
Calcium (mg)	642.97	425.55	788.15	788.87	864.8	415.19	182.9	380*	380*	5.752	<0.01
Magnesium (mg)	231.96	248.52	337.24	403.9	237.2	359.64	121.21	140**	120**	2.803	0.005
Phosphorus (mg)	1381.58	778.93	1808.29	1357.36	514.16	1217.55	584.34	220**	220**	2.803	0.005
Iron (mg)	8.65	11.07	14.41	24.21	7.39	14.75	9.61	4.4*	5.2*	4.316	0.002
Zinc (mg)	12.06	9.79	11.72	9.07	4.19	13.78	8.76	3.76*	3*	4.478	0.002

TDG: Turkish Dietary Guideline. * One-Sample T-test, significant. ** One-Sample Wilcoxon Signed Rank Test, significant at $p < 0.05$ level.

Table 3. The mean carbon and water footprint levels of traditional menus according to their regions and EAT-Lancet Planetary Diet.

Regions	Carbon footprint (kg CO ₂ eq/d)	H, <i>p</i>	Water footprint (L/kg/d)	H, <i>p</i>
Marmara	4.45 ± 0.56	H: 6.774, <i>p</i> : 0.453	4165.03 ± 386.95	H: 6.854, <i>p</i> : 0.444
Aegean	4.30 ± 0.77		2564.90 ± 309.59	
Mediterranean	4.10 ± 0.48		3722.66 ± 270.46	
Black Sea	2.70 ± 0.28		2270.18 ± 175.12	
Central Anatolia	2.01 ± 0.23		1132.14 ± 101.18	
East Anatolia	4.75 ± 0.62		3466.69 ± 360.05	
Southeast Anatolia	5.54 ± 0.55		3357.32 ± 273.85	
EAT-Lancet Planetary Diet	1.51 ± 0.21		1070.78 ± 69.37	

Kruskal-Wallis test.

Black Sea and Central Anatolia, followed by the EAT-Lancet Planetary Diet. For water footprint, the ranking from highest to lowest was Marmara, Mediterranean, East Anatolia, Southeast Anatolia, Black Sea, Aegean, Central Anatolia and the EAT-Lancet Planetary Diet. However, no statistically significant differences were observed between the traditional menus and the EAT-Lancet Planetary Diet regarding their carbon and water footprints ($p = 0.969$, and $p = 0.661$, respectively).

Discussion

Turkish cuisine, rich in cultural heritage, holds a unique place among world cuisines. Evaluating the nutrient profile, carbon footprint and water footprint of its traditional dishes is crucial for both health and sustainability, and these insights could guide the development of environmentally conscious food policies by illuminating the environmental impacts of dietary habits. According to our findings, traditional dishes from all regions exceed the TDG energy recommendations, with Eastern Anatolia showing the highest values. This may be attributed to high fat and carbohydrate content, cooking techniques such as frying, and the inclusion of local desserts on menus. Similarly, protein levels in all regions exceed TDG recommendations, with the Marmara region leading. The use of animal products, including chicken, milk and cheese in soups, desserts and salads, likely contributes to the higher protein content. Fat and saturated fat levels are also notably above recommended values, with the Eastern Anatolia region again showing particularly high carbohydrate levels due to traditional dishes like pastries and kadayif.

There are differences in some macro and micronutrient levels between regions. Dietary fiber, a vital component of a healthy diet, aligns well with Mediterranean diet recommendations; the Mediterranean region, in particular, exhibits high fiber content, with many regions exceeding the recommended values. Cholesterol levels, however, surpass recommendations in several regions, with Marmara recording the highest values, while the Black Sea region shows comparatively low cholesterol. Nutrient analysis shows that all menus meet requirements for vitamins A, K, B₁, B₂, B₆, B₁₂, folic acid, potassium, phosphorus and zinc, underscoring the nutritional richness of Turkish cuisine. However, sodium content is high across all regions, and calcium levels are below the recommended levels in the Southeast Anatolia menu. The observed variations in macro and micronutrient levels across Türkiye's regions can be attributed to several factors. Agricultural and climatic conditions play a significant role in shaping regional diets, as they determine the availability and nutritional composition of local ingredients. Traditional cooking methods also shape nutrient profiles. Techniques such as frying, common in Eastern Anatolia, increase fat content, while boiling or steaming, prevalent in the Aegean region, help preserve essential vitamins and minerals (Solmaz and Altiner 2018; Üçtuğ et al. 2021). Cultural preferences further accentuate regional differences. For example, lamb-based dishes and butter-rich recipes in Southeast Anatolia reflect a cultural emphasis on high-energy diets, whereas the Black Sea region's reliance on carbohydrate-dense foods, like corn-based bread, highlights the role of local grains in sustaining dietary patterns (Üçtuğ et al. 2021; Karaçil Ermumcu et al. 2024). In summary, Turkish cuisine

features high energy, carbohydrate and cholesterol values, while also being rich in protein, fiber and diverse nutrients. Nutrition is essential not only for health, but also for environmental sustainability, underscoring the importance of assessing the environmental impact of food choices. The findings of this study support the hypothesis that the nutritional profiles of traditional Turkish menus differ significantly from the recommended intake levels from the TDG. The high levels of energy, fat, and sodium observed in regional Turkish menus may contribute to increased risks of obesity, hypertension, and cardiovascular disease (Willett et al. 2019). For instance, the frequent use of red meat, butter, and salty foods in some regions surpasses dietary guidelines, emphasizing the need for moderation. However, components such as olive oil, legumes, and vegetables offer significant health benefits, aligning with the Mediterranean diet. The promotion of healthier preparation techniques, such as reducing salt and replacing saturated fats with olive oil, could help mitigate these risks while preserving the cultural essence of Turkish cuisine.

Southeast Anatolia has the highest carbon footprint, at 5.54 kg CO₂ eq/day. The carbon footprint, a measure of GHGE from food production to consumption, is influenced by factors such as energy use, agricultural practices, transport, processing, waste management and packaging. High carbon emissions in Southeast Anatolia may result from red meat consumption, the use of animal-derived products (such as butter), cooking methods that require long-term energy and specific climatic conditions (Nabipour Afrouzi et al. 2023). The Eastern Anatolia region follows with 4.75 kg CO₂ eq/day, while Marmara (4.45 kg CO₂ eq/day) and Aegean (4.30 kg CO₂ eq/day) also show relatively high values. The Mediterranean region has a lower carbon footprint at 4.10 kg CO₂ eq/day, while the Black Sea (2.70 kg CO₂ eq/day) and Central Anatolia (2.01 kg CO₂ eq/day) regions exhibit notably lower values. According to Bayram and Ozturkcan (2023b), similar results reported that the West Marmara diet had the highest GHGE levels, at 2983.79 g CO₂-eq. per person per day, followed by the Istanbul diet and Southeast Anatolia diet (2941.73 g CO₂-eq. per person per day and 2935.08 g CO₂-eq. per person per day), whereas the Mediterranean diet had the lowest, at 2623.90 g CO₂-eq. per person per day (Bayram and Ozturkcan 2023b). This small difference may be due to the fact that carbon footprint analyses are performed with different datasets. Additionally, these lower carbon footprints in the Mediterranean and Black Sea regions may be attributed to agricultural practices, dietary habits and food system characteristics, as the diets in these regions are predominantly plant-based. Increased vegetable, fruit, cereal and legume consumption is associated with reduced carbon emissions compared to diets rich in animal products. Meat and dairy contribute significantly to the greenhouse gas emissions of the food systems, while plant-based diets substantially reduce them. In line with our findings, Saleki et al. found carbon footprints of 3.4 kg CO₂ eq/day for regular university refectory menus in Türkiye, compared to 0.9 kg CO₂ eq/day for sustainable menus (Saleki et al. 2023). Carbon and water footprints of both the traditional menu and EAT-Lancet Planetary Diet were compared. The carbon footprints of the EAT-Lancet Planetary Diet were found to have 1.51 ± 0.21 kg CO₂ eq/day and it has the lowest value. Although the planetary diet has the lowest value of CFP, there were no significant differences with traditional menus. The similarities in carbon and water footprints between the traditional Turkish menus and the EAT-Lancet Planetary Diet may be attributed to the high inclusion of plant-based ingredients, such as legumes, grains, and vegetables, in many traditional Turkish dishes. This finding suggests that regional adaptations of traditional Turkish cuisine could align even more closely with the principles of sustainable eating by minimizing the use of animal products and optimizing portion sizes

Water footprint measures the total water usage in producing a food product (Guimarães et al. 2024), and analyzing water footprint in Turkish cuisine is critical for enhancing production efficiency and conserving water resources. The Marmara region has the highest water footprint at 4165.03 L/kg, followed closely by the Mediterranean region at 3722.66 L/kg. Water footprint is influenced by factors such as product type, agricultural practices, climate, supply chain, population density and sustainability measures. Animal-based foods in particular demand high water consumption, while environmental factors like irrigation efficiency and climate change further affect

water resource availability (Xu and Li 2020). The high-water footprint in these regions may be due to the meat and dairy content in traditional menus, especially cheese used in desserts. By contrast, the Aegean region has a lower water footprint of 2564.90 L/kg. The Black Sea and Central Anatolia regions exhibit even lower values, at 2270.18 L/kg and 1132.14 L/kg, respectively, with Eastern and Southeast Anatolia falling at mid-levels. Although there was no significant difference between traditional diets, the lowest water footprint was found to be the EAT-Lancet Planetary Diet with 1070.78 ± 69.37 . Low water footprints may reflect a reliance on plant-based foods, local and seasonal ingredients, efficient irrigation, minimal processing and sustainable agricultural practices. Plant-based foods generally consume less water than animal products, and local, seasonal ingredients reduce water losses associated with transport (Mekonnen and Gerbens-Leenes 2020). Türkiye's Water Footprint Report calculates per capita water usage at 5412.7 L/g (Turan 2017). A study conducted in Türkiye assessed personal water footprints among 3,431 adults and determined that meat and dairy products contributed the most to water footprint. The average water footprint due to food consumption was reported as $511.9 \text{ m}^3/\text{year}$ for individuals aged 18–40, $525.4 \text{ m}^3/\text{year}$ for those aged 41–64, and $407.7 \text{ m}^3/\text{year}$ for those aged 65 and older (Karaçil Ermumcu et al. 2024). In a study by Vanham et al., dietary water footprints in 13 Mediterranean cities ranged from 3277 to 5789 L/g per capita, with a 19–43% reduction potential for a Mediterranean diet (Vanham et al. 2016). In contrast, high water values in the Mediterranean region in this study may be due to traditional dishes with substantial meat and dairy components. The hypothesis that the water footprint of traditional Turkish menus is significantly influenced by dietary patterns, with animal-based menus having higher footprints, is partially supported. The EAT-Lancet Planetary Diet emphasizes plant-based foods while limiting red meat and dairy to reduce environmental impacts. Traditional Turkish cuisine aligns with these principles through dishes like lentil soup, bulgur pilaf, and vegetable stews, which have low carbon and water footprints. However, regional variations, such as the heavy use of lamb and dairy in Southeastern Anatolia, exceed the diet's recommended allowances for animal-based products. Additionally, traditional Turkish diets often include larger portions of grains and bread, which may surpass the EAT-Lancet guidelines for balanced caloric intake. These findings highlight opportunities for aligning Turkish cuisine more closely with planetary health principles by encouraging plant-based alternatives and portion control while preserving cultural identity.

To reduce the environmental impacts of traditional Turkish cuisine, several actionable interventions and policy recommendations can be adopted. Substituting red meat with plant-based alternatives such as legumes, nuts, or poultry can significantly lower greenhouse gas emissions and water usage. Studies have shown that even small dietary adjustments toward plant-based foods can reduce emissions by up to 35% (Aleksandrowicz et al. 2016). Promoting seasonal and locally sourced ingredients minimizes transportation emissions and supports local economies, an approach emphasized by the FAO's guidelines for sustainable diets (Dooren et al. 2024). Denmark's Food-Based Dietary Guidelines provide an example of integrating climate considerations into public health strategies, advocating for plant-rich diets and reducing food waste (Dooren et al. 2024; Trif et al. 2024). Lastly, traditional Turkish practices, such as utilizing leftovers for soups and stews, should be promoted alongside food waste recycling programs to further reduce environmental footprints. These interventions align with global goals for sustainability while preserving cultural identity.

This study has some limitations and strengths. The limitations include difficulties in data collection and representativeness of dishes, uncertainties in carbon footprint calculations and variations in dietary profiles. Changes in dietary habits due to modernization and socioeconomic factors may make it difficult to accurately reflect the nutritional value and sustainability of regional dishes. Modernization and socioeconomic changes have significantly impacted traditional dietary patterns in Türkiye. Urbanization has led to increased consumption of processed and convenience foods, often at the expense of traditional cooking techniques and ingredients (Popkin 2017). Economic factors, such as income disparities and rising food prices, have influenced the accessibility of certain regional specialties, particularly those reliant on

expensive animal-based or local ingredients (Drewnowski and Darmon 2005). Additionally, globalization has introduced new dietary trends and fast-food culture, which can lead to a homogenization of food preferences and a decline in the consumption of traditional dishes (Hawkes 2006). These changes not only affect the nutritional profiles of diets but also alter their environmental footprints, as processed and imported foods typically have higher carbon and water footprints than seasonal and locally sourced ingredients (Burlingame and Dernini 2011). Addressing these challenges requires targeted strategies to preserve traditional dietary patterns while adapting them to modern lifestyles through education, policy interventions, and promotion of sustainable food systems. Also, Google Trends data was used for menu selection. Since online search trends are based on the interests and preferences of individuals with internet access, they may not accurately reflect rural areas or traditional culinary practices. Furthermore, factors such as media influence, seasonal trends and viral content may limit the representativeness of the selected dishes to actual consumption habits. This calls for caution in generalizing that the results accurately reflect the culinary habits across Türkiye. In future research, it is recommended to supplement Google Trends data with methods such as ethnographic research or field studies. Additionally, The SEL database does not account for region-specific nuances such as the traditional preparation methods, local ingredient sourcing, and cultural variations in food consumption. Carbon and water footprint values in the SEL database are based on studies conducted over a range of years (1998–2019). This time span might not capture recent advancements in agricultural technologies or shifts in dietary practices that could influence the environmental impact of food production. The database primarily focuses on production, processing, and distribution stages but often excludes consumer-stage emissions, such as energy use for cooking or waste generation. Traditional Turkish dishes, which often require energy-intensive cooking methods (e.g. long simmering times for stews), might have underestimated carbon footprints in this analysis. Some traditional dishes include ingredients with varying footprint values depending on the production system (e.g. organic vs. conventional farming). The database's use of average values might oversimplify these variations, particularly for complex recipes involving multiple ingredients. As a result, the calculated footprints may not fully represent the environmental impact of certain dishes unique to Türkiye's regions. However, this study is the first study that shows the nutrient profile and sustainability of the traditional menus of different regions in Turkish cuisine. Additionally, it has a reliable selection of traditional menus via the Google Trends tool. Furthermore, the traditional diets and EAT-Lancet Planetary Diet were evaluated in terms of carbon and water footprints.

Conclusion

This study highlights the nutritional and environmental implications of traditional Turkish cuisine, emphasizing its plant-based foundation while identifying challenges such as high energy, fat, and sodium levels in some regions. Vegetarian dishes align with sustainability frameworks like the EAT-Lancet Planetary Diet, but red meat and dairy usage raise health and ecological concerns. Promoting plant-based alternatives, local ingredients, and eco-friendly cooking techniques can preserve cultural identity while advancing sustainability and public health. Future research should explore sociocultural factors shaping dietary habits and region-specific sustainable diet models.

The findings offer actionable insights for stakeholders. Policymakers can integrate them into dietary guidelines to encourage plant-based diets, local sourcing, and waste reduction. Dietitians and public health professionals can advocate for portion control and reduced sodium intake while preserving cultural authenticity. Chefs and the food industry can adapt traditional recipes with eco-friendly ingredients, and educators and community leaders can promote sustainable eating practices through awareness campaigns. These strategies highlight Turkish cuisine's potential to harmonize cultural heritage with ecological and health goals.

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ORCID

Zehra Margot Çelik  <http://orcid.org/0000-0002-4622-9252>

Hatice Kübra Barçın-Güzeldere  <http://orcid.org/0000-0003-0217-0938>

Elif Ede-Çintesan  <http://orcid.org/0000-0001-6103-2784>

Hatice Merve Bayram  <http://orcid.org/0000-0002-7073-2907>

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